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PROCEEDINGS OF THE PHILADELPHIA FOUNDRYMEN'S ASSOCIATION.

The regular monthly meeting of the Foundrymen's Association was held at the Manufacturers' Club, Philadelphia, on Wednesday evening, April 6, with President Wanner in the chair.

Secretary Evans announced that the executive committee had no special report to make, except that business was very much better than it had been. He announced the name of George T. Johnson, Philadelphia agent for the Andover Iron Co., as an applicant for membership. Mr. Johnson was unanimously elected. The treasurer reported a balance in the treasury of $1,680.57, and all bills paid.

Mr. Evans then called upon the members present to give their views upon the condition of trade.

John Fitch, of Hanover, said that business was very much improved.

Mr. McArdle, of Plainfield, N. J.: "Our works are in a very flourishing condition, and all the shops in our neighborhood are prosperous."

Mr. Messick, of the Pusey & Jones Co.: "We have plenty to do; much more than at this time last year."

Mr. Stirling, of Harlan & Hollingsworth: "The outlook down our way is splendid, and there is every prospect of even better times."

Mr. Sites, of York: "We have more work than we can attend to. So much so, that just as soon as I get home again, I propose to start night work."

Mr. Harper, of Chester: "Steel castings are booming, and every shop in our vicinity is full of work. We have all we can attend to, and some other shops, within my knowledge, are simply over-crowded with work."

Mr. Moore, of Stanley G. Flagg & Co.: "We are running day and night, and are taking all the molders we can get."

Mr. Insley, of the Link Belt Engineering Co.: "We are using a great many castings, more than ever before."

Mr. Wright: "We have a great volume of business, but prices are unsatisfactory."

Mr. Johnson: "Our foundries are in good condition."

Mr. Davies: "Business is fair, but prices are not what they ought to be."

Mr. Pole, of Bement, Miles & Co.: "We are extremely busy, with all the work we can possibly attend to."

Mr. Evans then read the following memorandum concerning an achievement of Henry Challingsworth, of the Phoenix Iron Co., Phoenixville, Pa.:

MENDING A BROKEN ROLL WITH CUPOLA STEEL.

"Mr. Henry Challingsworth, superintendent of the Phoenix Iron Co.'s foundry at Phoenixville, Pa., is the first man to accomplish the feat of splicing a 24-inch steel beam roll with steel melted in an iron cupola. In December, 1897, a 10-inch beam 'top roll' in the Phoenix Iron Co.'s three-high 24-inch mill snapped short off at the shoulder, the fracture being nearly vertical. The roll was handed over to Mr. Challingsworth at the foundry, who proceeded, by his own method to splice the same. He completed the

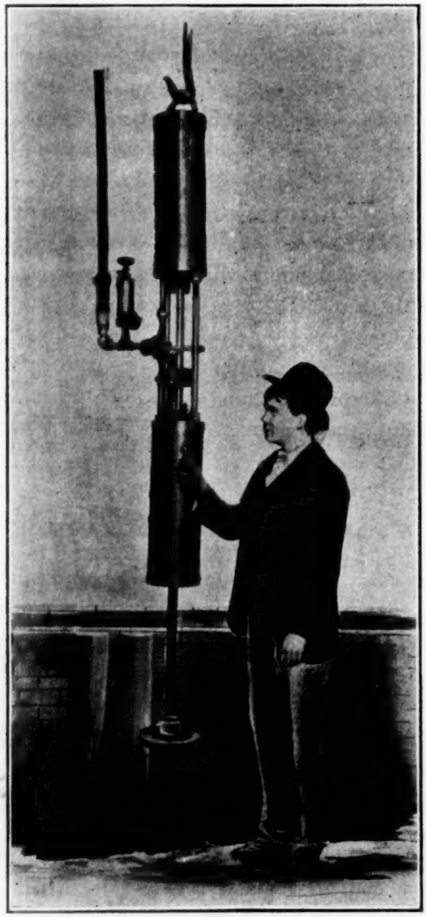
job and the roll was dressed and returned to the mills, where it has now been steadily at work for over three months and is pronounced to be in every way a decided success. The roll was 5 feet 6 inches long; 24 inches diameter—with 12-inch and 10-inch bearing and standard connections." Mr. Harper remarked that he had frequently seen pieces welded upon steel castings, and it was the consensus of opinion among the members that Mr. Challingsworth's feat, as briefly stated, was not particularly remarkable.

An extremely interesting paper, by George E. Matlack, of the Cramp Ship & Engine Building Co.'s foundry department, on "A New Patent Pneumatic Rammer," was then read by Persifor Frazer, Jr. Mr. Frazer prefaced his reading with a few remarks on the foresighted policy of Congress which made it necessary for the government in the present crisis to rush to foreign countries to buy warships much inferior in every way to those made here. He thought the present war scare offered a bright outlook for the foundry trade.

A PORTABLE PNEUMATIC RAMMER.

No doubt many of my hearers have stood frequently over a deep pit in a foundry, and watched with curious interest a gang of laborers ramming up in an aimless, monotonous fashion some large mold and wondered that in this age of advanced mechanical ideas no one has thought to apply to this class of work some device which would take advantage of the great field for economy. The new rammer, which has come in response to this call is from the brain of a thoroughly practical mechanical man, whose knowledge of the advantage of labor-saving devices, and the proper application of them has been derived from a wide and varied experience. The man to whom I refer is Mr. Joseph C. Cramp, superintendent of the power and plant repair department of the Wm. Cramp & Sons' Ship & Engine Building Co., of this city. It was, therefore, quite proper and natural that the idea of introducing an article of such mechanical neatness and such commer-

cial value should have originated in the mind of a thoughtful and practical man.



PORTABLE PNEUMATIC RAMMER.

Convinced that it was in his power to perfect a machine that would be of inestimable value to me in the foundry, I kept nag-

ging at him on the subject, and about a year ago I succeeded in getting him enough interested to put his ideas and thought into tangible shape, the result of which is this portable pneumatic rammer, which will practically revolutionize loam molding, and to a great extent large green sand work. For fully a year Mr. Cramp worked and puzzled and struggled on, I criticizing, Mr. Cramp trying again and again, disappointed but not discouraged, until at last he succeeded in giving me a tool that left nothing to criticize, and the rammer was a success.

The portable rammer consists of two vertical cylinders, held apart by stanchions containing pistons driven either by steam or compressed air, which is regulated by a simple but ingeniously contrived Corliss valve. The size of the cylinder is 3½ inches, the length of stroke is 4½ inches, and with an air pressure of 35 lbs. per square inch at the piston, it strikes 200 blows per minute, each blow with the butt rammer head covering an area equal to seven times the area of an ordinary hand rammer.

This device, which at once must suggest itself as scientific and practical, is suspended from a turnbuckle which is attached to a trolley on a movable crane, so as to enable it to move main pipe, running the entire length of the foundry. The crane is portable and can be shifted to any column, thereby covering any spot in the shop.

For the last two months it has been in successful operation every day, ramming up molds of all manner of shapes and sizes and weights—indeed it seems almost impossible to describe and explain the vast amount of work it does and the labor saved. There are very few molds that I have ever seen that by the use of this tool cannot be rammed up in one day. I am making at present some very large pumps that require a pit 30 feet long, 14 feet wide and 8 feet deep. According to our regular practice it would take about 25 men three days to ram it up ready for casting. With two machines and twelve men I very easily rammed it up in one day, not only saving in money paid for labor, but casting two days earlier, thereby saving considerable time in the room occupied by this mold. I also find that it increases the

capacity of my ovens, for I am able to cast the mold faster after they are dried, and do not have to wait for floor space to put the molds after they are dried.

The rammer itself is very simple and as yet has never gotten out of order, but is always ready. There are no breakdowns or giving out of little things, as very often occurs in new mechanical devices, causing constant irritation to a foreman.

Most any loam mold, with four men, can be rammed up in a day. By this I mean any large mold, say 10 feet in diameter, and 6 to 8 feet deep. Of course small ones can be rammed up in correspondingly quick time and the ramming is more even and far superior to that done by hand. As you all know, laborers, when ramming a mold, do so in a sort of aimless way. When the foreman's back is turned, the blow struck is not very hard, and very often the casting strains considerably. Any casting rammed up by this tool will be fully 10 per cent less in weight than when rammed by hand. I have been able to reduce materially my laboring force since using the rammer, and thereby reduce the running expense of the shop; for when I have no ramming to do the machine is idle and at no cost, whereas when hand is used you have the men around the shop drawing their pay just the same. Any tool in a shop to-day that will allow you to do away with men is a money-saver, even if it does not do work any cheaper, for the correct and great idea in the management of any business to-day is to have as few men as possible in your shop when you are able to supplant them by modern tools, since there are always lulls and times when you have surplus labor. It may be for a couple of days or it may be for a few hours,—we try to keep the men employed on odds and ends because we see we will want them in a few days. I know every foreman present will concur with me on this point.

I have been experimenting with the rammer mostly on ramming up loam molds, but since it has proved its great value there, I have been introducing it lately on large green sand work. In bedding in large green sand work, you all know the main point

is to have a goodly evenly rammed bed under it. Thus the rammer will do far superior and far quicker work than by hand.

The firmness of the ramming is at once made evident when you come to vent your bed. Any one present who has made large castings in green sand will appreciate at once the ramming of the bed in two to three hours that ordinarily would take two molders and helpers one to two days, and then not done as well as when using the rammer.

I am at present having some pene rammers made to put on in place of the butts; I will then commence ramming the molds up completely with the machine. Such is my faith in it that I have no doubt that in a few months all of my large castings in green sand will be rammed up with this new tool—that is, with the exception of the cope. How many of you present have hoisted out a large casting, and after digging out the pit, taken out your cinders and plates, have found a large hole in your floor confronting you. You may need this floor space badly, but you have no men to spare to ram it up, and you either have to do it at night or wait until you can spare the laborers to do it. Right here is where the rammer comes in. You can always spare two men—one to run the machine and one to fill in the sand—and in a very short time you have your pit rammed up even with your floor, there being no soft places for the next casting put there to strain, but a good hard evenly rammed floor.

With this rammer, whether the force of the blow is equal to 300 pounds or one pound—which can be very easily regulated by the turn-buckle—every blow struck will be of uniform force, consequently the sand will be rammed evenly and with the same force throughout every inch of its surface, and no straining of the metal in casting can possibly occur.

Another strange thing about the rammer: Although you use it for ramming up your molds you can change it and use it to dig your pit out by simply putting on a rammer with prongs. This will go around and break up the sand so that it can be very easily shoveled out. Instead of having hard digging you simply have shoveling.

I have already touched lightly on the advantage of reducing as much as possible the force of men employed in a foundry, or in fact in any establishment, and if you will permit me to enter a little more deeply into this subject, I will give you some reasons.

First of all, the fewer men you employ the smaller and less complicated is your pay-roll; the more will your foreman be relieved from enforcing discipline and surveillance, and be able to devote his time to perfecting his work. There will be less likelihood of strikes occurring and less damage if they should occur. A machine that will do the work of a man in the same time is more valuable than that man. But this tool will do the work of 15 or 20 men, and not only do it better, but in far less time; and when done you simply close a valve, and it is at rest until you need it again.

Before I close allow me to express my views on the subject of compressed air. I said that this rammer could be run either with air or steam, but for ramming in a foundry compressed air is far better power. The day is not far distant when it will be more widely used in all of our foundries. The pneumatic chipping tool has come to stay, and although my first experience with it was not favorable, I have changed my mind since getting the right tool, and I can fully commend its utility and cheapness in chipping castings. The sand blast is another appliance that can be attached economically to any air compressor and do good work. Most of you appreciate the use of air hoists, and I think a traveling crane run by air will give more satisfaction in most foundries than one run by electricity, for the simple reason that a crane run by air is not so complicated and does not need such skilled labor to run it or keep it in repair. Most any machinist understands air, and very few understand electricity. In our foundry this is not so apparent, as we have a corps of electricians at work all the time on the ships, and these are at my disposal at once in case of a breakdown; but I presume most of the foundries are not so favored.

My idea in referring to the use of air is to emphasize the fact that installing an air plant to run the rammer is a very useful and

paying investment, for you will be greatly surprised at the many things to which you will be constantly applying this power.

DISCUSSION.

Mr. Evans: In green sand work, in a pit, in filling the pit would a rammer of this kind be used to good advantage? Perhaps Mr. Pole could enlighten us on this point.

Mr. Pole: I have had pits in our shop take eight men the whole of three days to ram them up. A rammer of this description would be a good thing.

Mr. Stirling: What would be the cost of such a machine?

Mr. Matlack: It is not yet on the market.

Mr. Pole: It would be a handy machine to follow a molder around with.

Mr. Matlack: Yes. You could put a pene on it if you wanted. You have perfect control of it.

Mr. Seitz: I think it is a good thing, but I do not believe in a pene rammer on a pattern. You have your pressing machines to press your sand with. With a pene rammer you might have a scab.

Mr. Matlack: You can take the pene rammer off and butt afterward. You can strike heavy or light blows, just as you please. The rammer is only a wedge; with it you dare not go within three inches of your pattern. It rams in a straight line or locally at the whim of the operator, every inch of space being rammed perfectly.

Mr. Evans: In the paper you claim that there is a saving of 10 per cent in metal effected. I would like to know how it does that.

Mr. Matlack: The saving is apparent. In some cases this might not suit a foundryman, while in others it would. In big molds straining sometimes occurs, and this is because the mold is not rammed hard enough. Large castings are sometimes lost by straining.

Mr. Stirling: What is the weight of the rammer?

Mr. Matlack: Five hundred and sixty pounds. The machine can be run by steam or air, but steam power is not so convenient as air owing to the condensation of the steam.

Mr. Wanner: What are the possibilities of the rammer in ramming up pipe?

Mr. Matlack: One or two pipe makers have examined the machine, and they think they can ram pipe with it.

Mr. Cramp: The rod may be extended to 10 feet if required.

Mr. Evans: Supposing an ordinary foundry, without a compressed air plant, but with a traveling crane, wished to do loam work with this rammer. What rig would they require, and how much would it cost?

Mr. Matlack: A compressor would cost about $250, and the crane to swing on might be built for $50 or $60. The price of the rammer is not yet determined upon.

Mr. Messick: The rammer should be a very good thing. I do not think it should be operated by steam, though; the hot water dropping would make it bad for the man operating it. I suppose a light portable post crane could be used.

Mr. Cramp: Yes. A 12-inch I-beam, 12-inch jib.

The meeting then adjourned.

PROCEEDINGS OF THE WESTERN FOUNDRYMEN'S ASSOCIATION.

The regular monthly meeting of the Western Foundrymen's Association was held Wednesday evening, April 20, 1898, at the Great Northern Hotel, Chicago. The president, C. A. Sercomb, occupied the chair.

The following topical question was discussed: "Is it economical to ventilate a foundry artificially? What has been your experience?"

Mr. Carver: So far as our foundry is concerned, we are situated out on the prairies where there is plenty of ventilation without any artificial means. From experience I am unable to give you any points.

Mr. Thompson: It cannot be possible to ventilate a foundry economically by artificial means. It would be cheaper merely to open the windows and let the air in. There might be a question whether it would be necessary to ventilate a foundry artificially, but I cannot see that it can be done economically.

Mr. Smith: In the case of smoke in the foundry, it is desirable that it should be removed, but as to the economy of it, I have no means of giving any information. It seems to me that the shops can be ventilated by windows, transoms, etc. The shop where I am is provided with fans for removing the smoke. I was once in a foundry where the shop had been cut in the side of a hill and the roof was practically level with the top of the hill, and they put domes over the shop for ventilation. We had eight extra domes over the roof, and in that case it paid.

Mr. Sorge: Is it not a matter of economy to ventilate the shop and remove the gases to enable the men to work?

Mr. Smith: I think that would apply to power ventilation. We often found it necessary in the shop referred to to employ fans also.

Mr. Sorge: It is some time since this question was first brought up, in connection with the discussion which was had

here one evening referring to the division of labor. The question was whether it would not be a fair thing to ask the foundrymen to ventilate the foundry artificially, to enable the molders to work while pouring was going on; whether it would not be economy, not only in the operation, but because the output could be increased so largely as to decrease the cost of ventilating plant. I think if you attempted to ventilate a foundry by means of a chimney, you would find it very difficult to get sufficient volume of air to keep the foundry clear. The only effective way of doing it would be by some artificial means, as by a fan that would remove a large amount of air at one time.

The question was then taken up: "What is your experience as to the effect upon coke of exposing it freely outdoors?"

Mr. Stantial: I have all of my coke outdoors, but it does not stay in the pile long enough to deteriorate from exposure. I have never found that wet coke has given any poorer results than dry coke. The only thing I have found with coke that has been exposed a long time is that it sometimes softens.

Mr. Sorge: What effect does it have upon the sulphur in the coke?

Mr. Stantial: I have used coke that has been kept in a shed and coke that has been exposed to the air, and it never made any difference whether it was out in the air or in a shed.

Mr. Sorge: Would not sulphurous coke be improved by exposure?

Mr. Stantial: Not necessarily.

Mr. Vrooman: Is water a solvent of sulphur?

Mr. Sorge: Yes.

Mr. Carver: I used to think it was almost a necessity to have big coke sheds to keep the coke well housed, until by necessity we have been driven to keeping a supply out of doors. When I was in Detroit at the last session of the American Foundrymen's Association, I was surprised to see several hundred tons of coke at the Michigan Stove Co.'s works stored directly out in the open air. I asked Mr. Keep if he considered that it was good policy in

every respect to keep it out of doors. He said yes. We keep our supply of coke out of doors, and in watching it closely I see that sulphur in the coke is drawn to the surface, and if there is anything in water as a solvent of sulphur it will take a large per cent of the sulphur contained in the coke.

Mr. Stantial: Have you had any analysis made to show this, or is it merely your opinion?

Mr. Carver: It is my opinion from the condition of the coke. You take a piece of coke as it comes to you and it looks perfect. After being stored a while out of doors you will find it spotted on the exterior and discolored from the sulphur being carried to the surface. It will look as if it was dangerous to use, but the fact is the sulphur has been drawn to the surface and possibly practically absorbed by the atmosphere. Furthermore, I think that if the coke can be treated to a good shower-bath the melting power would be improved and you would get better iron. I notice that, particularly on a wet day when we are compelled to use wet coke, we get better iron than when the coke is thoroughly dry.

Mr. Sercomb: You do not think that it softens under exposure?

Mr. Carver: I have seen no indications of it.

Mr. Sorge: You will find the same effect on pig iron that Mr. Carver describes as finding on the coke when it is exposed to the air. You will find the same surface discoloration.

Mr. Stantial: Have you kncwn of any analyses being made of coke that will show this tendency?

Mr. Smith: I would like to ask Mr. Carver if it is not a theory that the spotted effect on the coke is caused by exposure? If a person had asked me, I would naturally have said that it would be detrimental to coke to leave it exposed, because I would have supposed that it would soften. As to the extra heat that Mr. Carver explains is due to the coke absorbing water, I think that could be explained in this way: The coke would not be consumed until it reached the proper point in the cupola and the combustion

would not take place as quickly. It looks as though the moisture in the coke had assisted combustion. If it were possible to take the sulphur from the coke by exposure, there is no doubt but that the coke men would have done it.

Mr. Carver: I do not know what particular chemical action caused the discoloration, but I took occasion to take one sample that was badly discolored and send it to our coke men with a complaint about the coke and asked them for an honest analysis. They gave me the analysis. It was .95 per cent sulphur. They apologized and said that no such coke should have been sent us. When we received that coke, it showed no such indications of sulphur. You would not have thought that there was anything wrong with it at all. This piece had been exposed to the air for perhaps two months, and I selected it from the fact that it was so badly spotted and discolored, and the results proved that it was very high in sulphur.

The secretary read the following letter:

Sharpsville, Pa., April 11, 1898.

Gentlemen:—I regret that my communication to your last meeting was not rightly understood. I merely claimed that it was not necessary to determine how much graphitic or combined carbon pig metal contained, and cited chilled and sand cast pig metal made from the same iron to illustrate the question. I do not deny that it is not often essential to know the total carbon contents of pig metal, but that is another question wholly foreign to what my communication presented. I had hoped to see my point discussed, as many seem to think it necessary to determine the relation between the graphite and combined carbon in the pig metal in order to define its grade.

Yours truly,

THOS. D. WEST.

Nominations for officers, board of directors and editing committee to be voted upon at the May meeting were then made and the meeting adjourned.

PROCEEDINGS OF THE PITTSBURG FOUNDRYMEN'S ASSOCIATION.

Thirty-four members were present Monday night, April 25, at one of the most successful meetings of the Pittsburg Foundrymen's Association since its organization two years ago. The meeting was held at the association rooms in the Builders' Exchange and was presided over by President Robert Taylor.

Mr. Paul Kreutzpointer, of Altoona, presented a paper on "Difficulties Encountered in Testing Cast Iron." Mr. Kreutzpointer had provided samples of iron and steel, and illustrated the various peculiarities in structure as they were passed. The paper was much enlivened by the explanatory remarks of Mr. Kreutzpointer interspersed throughout its reading. A recess of ten minutes was taken for closer inspection of the samples. The discussion later on was participated in by Mr. Frank, Dr. Moldenke, Mr. West and Mr. Kebler, and Mr. Kreutzpointer spoke further as to causes of segregation, bringing out the point that excessive sulphur and phosphorus segregated more readily than other elements, thus rendering the points of segregation particularly weak. It was wise, therefore, after care had been taken to get a correct mixture, to postpone pouring of the iron as long as practicable, avoiding both extreme heat and rapid cooling.

DIFFICULTIES ENCOUNTERED IN TESTING CAST IRON.

The question of small economics is forcing itself more and more upon the attention and the pocketbook of the manufacturer. Testing the physical qualities of materials—of cast iron, in our case—is one of these economics, because it is a prevention of waste; and since waste pays no dividends it is obvious that methods or measures which prevent waste are of money value in direct proportion to the amount of waste prevented. Yet, whenever we begin to try to squeeze metals into the straight-jacket of methods, rules and specifications, we encounter certain difficulties which we cannot overcome without knowing their origin.

Metals, in their formation, possess the essential conditions of minerals, of rocks. The fact that metals are generally malleable does not alter the case. There is iron in nearly all rocks, and if there is more in one class of minerals than in another, enough to make it a metal and malleable, this is merely incidental. However, cast iron is not malleable; hence it approaches the nature of rock more than any other variety of carbonized iron. Mr. H. M. Howe, in his celebrated work, "The Metallurgy of Steel," page 3, says: "In the present stage of our knowledge it seems probable that the conditions in a solidifying steel ingot, and perhaps in many other alloys and similar compounds, resemble those in a solidifying crystalline rock. For we find that the chemical condition of the components of the solidified steel and the size, and, probably, the arrangement of its individual crystals are affected according to now unknown laws by changes in its ultimate composition, and by the conditions which precede and accompany its solidification and cooling. The influence of cooling on the structure of steel is readily recognized. Slow, undisturbed cooling induces coarse crystallization. If the metal be vigorously hammered during slow cooling, the structure becomes much finer; if the cooling be sudden, extremely fine structure results. That other and now unguessed conditions profoundly alter both the mineral species and the structure of steel, and that changes in ultimate composition modify both species and structure of steel, as of crystalline rock, in most complex ways, is indicated by the utterly anomalous relations between the ultimate composition and the mechanical properties of steel. This anomalousness, which has puzzled so many, is readily explained by the close resemblance between the conditions of the formation of rock and of ingot, which not only shows us why we do not discover these relations, but that in all probability we never can from ultimate composition. The lithologist who attempted today to deduce the mechanical properties of a granite from its ultimate composition would be laughed at. Are our metallurgical chemists in a much more reasonable position?"

It is hardly necessary for me to call your attention to the close resemblance of the foregoing to cast iron, with the only difference that cast iron is not malleable, like cast steel. In general appearance there is little difference between the fractured surfaces of cast iron and cast steel. Having familiarized our minds with the idea that cast iron and rock closely resemble each other in structure and that the formation of this structure is in turn subject to the same conditions and influences, both in rock and cast iron, we may proceed a step further and, under the guidance of the teachings of the science of molecular physics, try to ascertain what takes place during the process of cooling in a piece of rock and thus possibly obtain a clue to many of the perplexities obstructing the path upon which we try to reach the goal of good, sound, strong castings.

Before entering, however, upon a detailed discussion of this point, let us see how these perplexities manifest themselves. Only the other day I made some tests of cast iron with the following results. The shrinkage ran all the way from 8-100 to 13-100 of an inch, while the transverse strength varied from 14,000 to 22,000 pounds. The test pieces were two inches square; supports were 12 inches apart. Some of the results varied from 14,000 to 19,000 pounds, while the shrinkage remained uniformly at 8-100 of an inch. There were tests with a strength of 14,000 pounds and a shrinkage of 10-100 of an inch, and two tests with a strength of 20,000 pounds and also a shrinkage of 10-100 of an inch. There was a test with a strength of 18,200 pounds, 16-100 of an inch shrinkage and 1-16 inch chill; while the next test gave also 18,200 strength, but a shrinkage of 11-100 of an inch and $\frac{1}{8}$ of an inch chill. All these tests were from the same mixture, cast under the same conditions and the manner of testing was identical in every case. Since you are only too familiar with these perplexities, it is not at all necessary to multiply cases.

In order to produce a crystalline body, like rock, steel, or cast iron, or the crystals of minerals of all kinds, there must be a solution. In such a solution there must be dissolved, and be

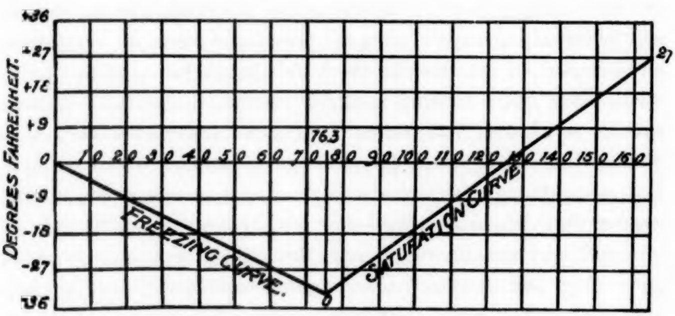
held in suspension, a certain percentage of chemical elements which, when out of that solution, by one cause or another, form themselves into crystals of various shapes, according to the natural affinities of these elements and the laws of crystallization, whatever these may be. A liquid, however, be it water or molten iron, cannot hold the dissolved chemical elements in solution beyond a certain degree of heat, nor any surplus of chemical elements with which the solution may be surcharged or supersaturated. As soon as a certain degree of heat is reached, lower than the one at which all the chemical elements are, and can be held in solution, separation begins, and the elements thus separated coagulate and arrange themselves into crystals of various forms. Fluid cast iron and steel being a combination of carbon, silicon, manganese, sulphur, phosphorus, iron, and other elements, it is a matter of great practical importance and interest to the steel maker and foundryman that the combination of iron and other elements, which he holds liquid in his furnace or cupola, consists of the right proportion so as to form well-developed crystals on cooling, of maximum hardness and cohesion, which in turn will result in maximum strength, or ductility, or both, in the resulting metal; and, as a natural consequence, in maximum strength, safety, and economy of the structure for which such metal is to be used.

The author therefore hopes that this distinguished audience may not consider it a waste of time to become somewhat acquainted with the manner of crystallization eventually resulting in the difficulties which we encounter in trying to establish uniform methods of testing cast iron, or in our daily work of testing in general. Even if we are often unable to obviate the causes of these difficulties, nevertheless, the knowledge of their possible source will enable us to work more intelligently and more comprehensively, just as the man seeing the source of danger is better able to make use of his wits and resources to guard against its consequences than if he groped about in the dark, as it were.

The power of a metal to resist the forces which tend to destroy it is a function of the uniformity of structure of the metal. Thus, given an ideal chemical combination of iron and other elements, or liquid mass of metal, and conditions of subsequent cooling preventing a uniform distribution, through every crystal, of the proper percentage of the elements, leave more in one place than in another, then the natural consequence will be that some crystals in one portion of a casting will be more fully developed, will be larger, stronger, better fitted for work, than the crystals in another part of the casting where the proper proportions of elements have been wanting, and the crystals were starved, so to speak, for want of proper food, and as a consequence are puny, ill-shaped and weak in body. But not only that. There being a surcharge or super-saturation of the metal in one place, it may happen that the solution is of such a kind as to be unable to hold just such a percentage of a given chemical element, and no more, on cooling, and then we encounter that baneful difficulty in castings of iron and steel—segregation, which means a spot or portion of an ingot or casting where the surplus of chemical elements is concentrated, either because there was a surplus of them held in solution in the liquid mass, or because unfavorable conditions of cooling retained more of them in one place, that is, prevented uniform distribution of the elements, as pointed out above. Concerning segregation, we find a partial explanation of this phenomenon in Lehman's "Molecular Physics," page 740. It says:

"There is invariably a minimum of temperature controlling the melting and solidification of a given proportion of a mixture of elements. If a liquid mixture containing the given proportions of elements is cooled, then all the parts of the mixture solidify uniformly at a minimum temperature. If the mixture, however, is composed of proportions of elements not solidifying uniformly at a given minimum temperature, then the surplus of elements present will solidify at a temperature higher than the given minimum." The working of this law is illustrated in the accompanying diagram, which is taken from the work referred to.

"If water and salt are mixed, that is, if we take a solution of salt in water and the solution holds less than 76.3 per cent of salt, then, on cooling to a minimum temperature, or zero in the diagram, ice separates, or segregates out. Since, by virtue of this separating out of ice, or solidified water, the percentage of water to percentage of salt has been diminished, as a consequence the percentage of salt in the solution has been increased propor-



tionately toward the limit of 76.3 per cent, and at the same time comes nearer to the freezing point, or minimum temperature of that mixture which lies at 63.5° F. If, however, the solution contains more than 76.3 per cent of salt to 100 parts of water, then on cooling salt is separated, or segregated. Thus, by virtue of this separation, the solution comes nearer to that point where solidification takes place at a minimum of temperature. If the solution holds just the limited proportion of salt, 76.3 per cent, then neither ice nor salt is separated, or segregated out, until the solution is cooled to 63.5° F. The contrary happens if heat is applied to the solidified mass. As long as ice and salt is frozen, or solidified, in proportional limited quantities, then the solidified mass will become a liquid solution again at a minimum temperature. If there be a surplus of ice or salt then, in order to liquify that surplus, the temperature must be changed and raised. Thus there will be a constant temperature at which a solidified mass of properly proportioned ice and salt liquifies, just the same as with any other solid body."

Now, since liquid masses of metallic substances are subject to the same laws of crystallization as liquid masses of mineral substances—because iron is a mineral like quartz, the only essential difference being an excess of iron in the one and an excess of silicious matter in the other—we can readily conceive what an endless variety of action and reaction may take place, and probably does take place in a liquid mass of iron while it is being run out of the converter, the furnace or cupola, and while passing from the liquid state, quickly or slowly, as the case may be, into the solid state. If we comprehend the somewhat complex action of so simple a solution as water and salt, we can readily imagine the almost incomprehensible complexity of conditions arising in a cooling mass of cast iron, which, of all classes of cast metals, is composed of a maximum of elements besides iron and carbon, by the partial or complete absorption, saturation, equalization, segregation, exchange and interchange of the various elements, according to their affinity, the law of crystallization, degree of heat, of melting and rate of cooling. Thus, according to the example of the solution of salt water, we can imagine an excess of sulphur being segregated out at the point of saturation with sulphur of the other elements, provided there be sufficient heat and time in cooling to favor complete saturation of one element with another element, most congenial to its nature. Supposing that ideal state has not been reached, then we have a disproportion of elements, a want of equilibrium, as it were, whereby the physical qualities of the metal are influenced in a manner unknown and puzzling and not seldom very perplexing to both the foundryman and the engineer. And what happens with one element like sulphur will of course happen with any one of the other elements, or two or three of them at a time, according, not only to the percentage present of these elements, but also to the readiness of each one individually and all of them collectively, to absorb, to become saturated with one or all of the elements each or all can absorb, thus forming a chemical composition in complete equilibrium of elements, as distinct from a state where the elements are unbalanced chemically or form

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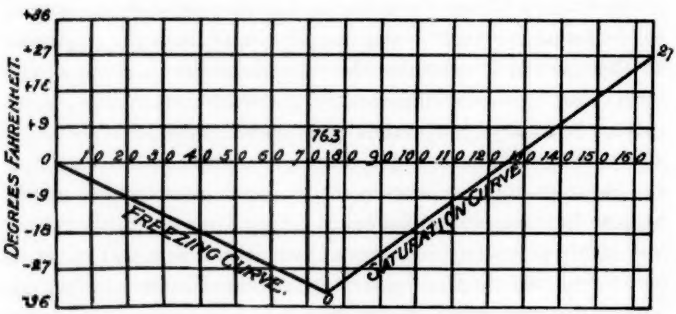

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merely partial mechanical mixtures. This is illustrated in the case of sulphur which has been found in dross and fine streaks, or in the well-known case of carbon segregating out in the form of graphite; more so, as you all know, if one or more elements are present which hinder the saturation of the iron with carbon. In these reciprocal effects of absorption and segregation, of solution and saturation of the varying and ever variable elements composing cast iron and steel complicated still more by the melting point and rate of cooling, we find the reasons and causes for the difficulties we encounter in testing cast iron and steel for their physical qualities, but more so in cast iron, because of the greater percentages and number of elements present and the variation of percentages of these elements.

In designing, therefore, or specifying test bars for standard use, these facts have to be taken into consideration in order to avoid dissatisfaction, distrust, confusion and misunderstanding. All the more so since, even with an ideal mixture, never attainable in everyday practice, the rate of cooling influences the physical qualities of cast iron in different portions of a casting differently, the portions cooling quickly being of finer grain, giving higher in tensile strength than the portions cooling more slowly, and therefore having a larger grain, or crystals, if you please. In steel ingots and steel castings, where the number and percentages of elements other than iron are much less than in ordinary cast iron, these influences of the melting point and rate of cooling do not become so prominent, and in the case of hammering or rolling the steel are equalized to a greater or less extent.

In this connection it may also be interesting to note the remarks of Prof. A. Martens, director of the Royal Prussian Testing Department, who is acknowledged to be one of the highest authorities on physical metallurgy, practical as well as theoretical. In a lecture on cast iron he said:

"Iron has, like water, the ability to absorb and dissolve various elements, according to the degree of heat, and like water,

on cooling, segregates out these elements, one after the other. Graphite, for instance, often separates from the iron when the latter leaves the furnace. * * * When the cooling has reached a certain point no more outward separation can take place, and the various elements become free within the mass. At that stage, it appears, a tendency prevails for certain elements to form groups and for these groups to locally separate or segregate out."

Thus, then, if we go down in the scale of temperatures from the highest degree of fluidity to the point of complete solidification, we have a series of formations of groups of elements, the last of which is decisive of the quality of the metal. Conversely, when heat is applied to the iron the various groups will not melt simultaneously, unless all the elements are proportional to each other, as in a solution of salt water, but will melt at various degrees of heat until at a sufficiently high degree of heat all the elements unite into one homogeneous mass, to separate again on cooling.

Thus far we have considered the question of solution and segregation as a whole affecting the physical qualities of cast iron. However, we become still more impressed with the reasons why we encounter difficulties in testing cast iron, if we examine into the details of the formation of crystals. Crystals are formed in a solution by the aggregation of certain elements forming eventually a body of angular form. This form is seldom symmetrical in the individual crystals of a mass of metal, apparently because of the crowding of each other while forming, and probably also because of the insufficient time in many instances given for their formation.

As no animal or vegetable product can grow without receiving nourishment from its surroundings, so crystals cannot grow without there being present a sufficiency of those substances in the solution, be that solution a liquid mass of metal, of mineral matter, or a watery liquid. As the roots of a plant extract, absorb and assimilate the nourishing substance on which it thrives, out of the earth surrounding the roots, so a growing crystal ex-

tracts, absorbs and assimilates out of the surrounding liquid those substances which, according to their affinities, are necessary to form a complete and perfect crystal. Therefore, as a plant grows the more vigorous and thrifty the more time is given and the more nourishing substance there is in the soil; similarly the crystals in a solution will be the more complete and perfect the more time there is and the more of the proper substance there is in the solution or cooling liquid mass of metal, other things being equal. Hence the well-known phenomenon of the crystals in iron and steel being larger, the slower the mass of metal cools. Thus we can easily perceive how crystals in iron may become larger or smaller, more regular or irregular, softer or harder, in one case than in another case where the amount of nourishing or crystal-forming substance is deficient in quantity or quality; just as one of two pieces of the same kind of rock is harder or softer or more regular in its texture than the other piece.

Guided by the above very brief consideration of the reciprocal effects of proportionality of chemical elements present in a solution of iron and other substances, of saturation, of melting point and rate of cooling, we find that the difficulties of determining the useful or commercial qualities of a metal by physical test (and incidentally also by chemical analysis), increase with the proportional increase of the chemical elements. And these difficulties are greatest in cast iron because of the heterogenous composition of its elements, which is apt to cause a variation in structure in a piece of cast iron and, as a consequence, a variation in quality in different parts. To represent this difference approximately is the difficulty when we attempt to devise means and methods of testing cast iron. How to overcome these difficulties and use a satisfactory and economical method of testing is not within the scope of this paper to discuss. The author's object was only to call attention to the presence of these difficulties, because, as said in the beginning, we can defend ourselves more intelligently if we know the nature and source of the danger we are going to encounter. Whatever these difficulties may be, they

should not be considered an obstacle to so intelligent and energetic a body of men as American foundrymen in general, and the Pittsburg foundrymen in particular, but rather an incentive to study the complex phenomena of physical metallurgy carefully, patiently and diligently. The result of these labors should be the much-desired uniformity in methods of testing, for which many of our foremost engineers and metallurgists are striving, through the agency of the International Union for the Unification of Methods of Testing the Materials of Construction.

A vote of thanks was tendered Mr. Kreutzpointer.

Mr. West's paper, on the "Need of Greater Uniformity in Pig Iron Analysis," which was read by title at the last meeting, was brought up for discussion and the secretary announced the receipt of a large number of letters on the paper, which we print below. Mr. West's paper is as follows:

NEED OF GREATER UNIFORMITY IN PIG IRON ANALYSIS.

While the past four years have witnessed a greater revolution in foundry practice than any like period, methods of making mixtures were never in the plight in which we find them to-day. The recent introduction of chemistry in founding has brought a realization of the impossibility of accurately judging the grade of an iron from fracture; yet there is still a prejudice with many against chemical analysis as a determiner of grades or as a basis for making mixtures. It is unfortunate that there are features involved in such analyses that give the opponents of chemistry some ground for throwing doubt upon it. All improvements have to combat with more or less prejudice and difficulty before they can establish themselves. For this reason those who know from experience the value of working by chemical analyses, should not be discouraged or sit still and let the retarding influences have full sway. The thing to do is to determine the factors that tend to prevent the general use of chemical analyses, and work to correct what needs correcting. The writer knows from experience some agencies that retard the general utilization of chemical analyses in making mixtures and in connection with this paper will cite a few of them.

At the outset two considerations may be stated. First, the founder who continues to make mixtures by judging the fracture of pig metal, will find that the iron in his castings is not always what he would like to have it and will often cause him heavy losses. Second, the principles underlying chemical analyses are established and their correct application gives the greatest assurance of attaining desired ends.

What is best to do, retain the old practice, or strive to perfect the new? This is a question that interests the maker of pig iron, as well as the consumer; for if the blast furnaceman can remove thereby any of the grounds of complaint by users of his product, he certainly has much to hope for from any progress toward perfecting analyses in making mixtures of iron. In one sense, the use of chemical analyses is but a comparative method, a guide to desired ends in making mixtures. With a certain percentage of silicon, sulphur, phosphorus, manganese and carbon in iron, other conditions being alike, as to fuel, etc., the progressive founder knows very closely just what physical results he may expect from his mixtures. If all the procedures have been correct, he will get expected results, but the difficulty lies in the possibility

TABLE 1.—COMPARATIVE ANALYSES OF FOUNDRY IRON.

No.	Laboratory.	Sil.	Sul.	Phos.	Man.	G. C.	C. C.	T. C.
1	*A	1.95	.011	.60	.63	3.35	.48	3.83
2	B	2.00	.010	.543	.56	....	...	4.27
3	C	2.02	.0045	.615	.56	2.99	.64	3.63
4	D	2.05	.010	.59	.69	3.20	.52	3.72
5	E	2.05	.007	.59	.60	3.41	.45	3.86
6	F	2.06	.011	.617	.62	....	...	3.85
7	G	2.06	.013	.579	...	....	...	....
8	H	2.11	.011	.617	.54	3.12	.80	3.92
9	I	2.13	.006	.503	.56	3.04	.44	3.48
10	J	2.158	.018	...	...	....	...	....
11	K	2.16	.015	.612	.550	....	...	....
12	L	2.19	.012	.591	.504	3.29	.82	4.11
13	M	2.21	.008	.61	.46	2.82	.36	3.18
14	N	2.21	.018	.600	.546	3.59	.32	3.91
15	O	2.22	.029	.54	.59	3.32	.25	3.57
16	P	2.224	.018	.603	.59	3.42	.29	3.71
17	P	2.219	.019	.614	.60	3.45	.23	3.68
18	P	2.228	.017	.610	.58	3.36	.40	3.76
Greatest Variation.		.27	.0155	.114	.23	.77	.59	1.09

*Corresponding letters in the four tables signify that analyses are from the same laboratory or firm.

of error. For example, if a founder has been receiving metal from one furnace that has a careful chemist and correct methods for determinations, he will obtain—providing no errors have been made in the shipment or charging of iron—the results counted on, in making his mixtures. But should this furnace change chemists or the founder secure iron from another furnace—changes occurring every day—we then find conditions that may destroy the comparative results of past practice in making mixtures. Such changes often cause bad castings or castings lacking in the physical properties desired, and may result in the furnace-man being censured or losing his trade. The trouble would have been avoided had the founder understood how to allow for the new chemist's methods of analysis.

TABLE 2.—COMPARATIVE ANALYSES OF BESSEMER IRON.

No.	Laboratory.	Sil.	Sul.	Phos.	Man.	G. C.	C. C.	T. C.
19	A	2.12	.060	.088	.73	3.19	.75	3.94
20	C	2.15	.048	.094	.93	2.78	.85	3.63
21	D	2.20	.056	.086	.91	3.10	.64	3.74
22	F	2.21	.051	.093	.95	....	...	3.81
23	S	2.25	.058	.090	.90	....	...	....
24	E	2.29	.048	.080	1.09	3.14	.57	3.71
25	R	2.30	.051	.087	.910	3.46	.50	3.96
26	B	2.31	.056	.083	.89	....	...	3.80
27	K	2.31	.060	.0865	.890	....	...	....
28	O	2.32	.051	.086	.84	3.06	.25	3.31
29	L	2.32	.055	.111	.809	3.51	.84	4.35
30	Q	2.37	.058	.087	.83	2.92	.82	3.74
31	P	2.445	.064	.086	.93	3.15	.67	3.82
32	P	2.402	.066	.084	.98	3.20	.68	3.78
33	P	2.413	.060	.086	.96	3.12	.72	3.84
Greatest Variation.		.32	.018	.031	.36	.73	.60	1.04

Two other factors are to be mentioned that affect the value of analyses: The character of the chemist's work and the purity of the chemicals used. Serious harm may be done by a careless chemist and such men should have no place in a chemical laboratory. Mistakes are liable to happen with any man, but where one is indifferent to them, no consideration should ever be extended. The strength and purity of chemicals is an important matter also. To guard against variations in this regard, chemicals are tested when received, and the impure rejected. To de-

termine the variation due to the method and to personal factors, the practice of standardizing drillings is followed. A chemist will first obtain from five to twenty pounds of clean, fine, well mixed drillings, out of which he will send samples for analysis to four or more chemists of known ability and accuracy in their work. The reports of these analyses may be two to five months in coming back. When all are received, he will accept the average as a standard. The labor and expense involved in procuring standardized drillings for testing chemicals or analyses are considerable, and suggest the question, Why cannot a central laboratory be maintained where all chemists dealing with cast iron could obtain standardized drillings, promptly and at a price comparatively small? As the writer is surrounded by blast furnaces

TABLE 3.—COMPARATIVE ANALYSES OF CHARCOAL IRON.

No.	Laboratory.	Sil.	Sul.	Phos.	Man.	G. C.	C. C.	T. C.
34	D	.95	.019	.89	1.76	2.90	.78	3.68
35	A	.97	.017	.96	1.77	3.10	.88	3.98
36	L	.97	.013	.929	1.795	2.94	.91	3.85
37	E	.98	.016	.91	1.80	3.01	.79	3.80
38	R	.98	.022	.957	1.98	3.25	.60	3.85
39	C	.99	.016	.956	1.90	2.84	1.02	3.86
40	T	1.00	.016	.952	1.90	2.69	.48	3.17
41	F	1.02	.017	.948	1.93	....	...	3.95
42	B	1.04	.021	.906	1.83	....	...	3.76
43	N	1.09	.033	.932	1.768	3.30	.44	3.74
44	P	1.161	.027	.931	1.85	3.20	.56	3.76
45	P	1.152	.025	.930	1.89	3.28	.44	3.72
46	P	1.157	.024	930	1.90	3.25	.48	3.73
Greatest Variation.		.21	.020	.067	.22	.61	.58	.30

and their laboratories, he has often thought of the steps that might be taken toward the establishment of such a standardizing laboratory for furnace work and iron founding.

In a paper read at the November meeting of this association, the writer solicited the addresses of chemists willing to analyze drillings, so that the results could be checked up and compared. It was surprising the great interest manifested in the work. As a result of this call, the writer has the pleasure of presenting in this paper 46 sets, or 273 separate analyses, from leading laboratories in the different iron working sections of this country and one from Canada. The samples the writer selected for the drill-

ings lie before you on the table. Here are three pieces of pig about 9 inches long, having ¾-inch holes drilled about 2½ inches deep from the face down, and as close as they could be obtained. The drillings from these samples of foundry, Bessemer and charcoal pigs respectively, were kept separate and those for each pig thoroughly mixed, so as to ensure that all samples sent out were exactly alike, as far as it was possible to get them by the use of pig metal. Pig iron was selected in place of making any special castings, so as to test particularly the ordinary practice followed at blast furnaces, in taking drillings from pig metal.

The writer's thanks are tendered to the various firms and chemists mentioned in Table 4, for so kindly furnishing the analyses seen in Tables 1, 2 and 3. It has taken no small expenditure

TABLE 4.—FIRMS AND CHEMISTS FURNISHING COMPARATIVE ANALYSES.

Laboratory.	Analyses.	Concerns Furnishing Analyses.
A	3 Sets.	Buffalo Furnace Co., Buffalo, N. Y., Frank Hersh, Chemist.
B	3 Sets.	Carnegie Steel Co., Cochran, Pa., J. M. Camp, Chemist.
C	3 Sets.	Tennessee Coal, Iron & Railroad Co., Birmingham, Ala., J. R. Harris, Chemist.
D	3 Sets.	Embreville Iron Co., Embreville, Tenn., F. E. Thompson, Chemist.
E	3 Sets.	Phillips Testing Laboratory, Birmingham, Ala.
F	3 Sets.	Illinois Steel Co., So. Chicago, Ill.
G	1 Set.	Spearman Iron Co., Sharpsville, Pa., W. E. Dickinson, Chemist.
H	1 Set.	Thomas Iron Co., Hokendauqua, Pa.
I	1 Set.	Everett Furnace, Everett, Pa., F. R. Bennett, Chemist.
J	1 Set.	Booth, Garrett & Blair, Philadelphia, Pa.
K	2 Sets.	Crane Iron Co., Catasauqua, Pa., H. A. Knauss, Chemist.
L	3 Sets.	Hamilton Furnace Co., Hamilton, Ontario.
M	1 Set.	James C. Foster, Sheffield, Ala.
N	2 Sets.	Warwick Iron Co., Pottstown, Pa., Wm. A. Stephan, Chemist.
O	2 Sets.	Andrews & Hitchcock Iron Co., Youngstown, Ohio.
P	9 Sets.	Dr. R. Moldenke, Met. Eng., Pittsburg, Pa.
Q	1 Set.	Bethlehem Iron Co., So. Bethlehem, Pa., A. L. Colby, Met. Eng.
R	2 Sets.	Claire Furnace Co., Sharpsville, Pa., D. K. Smith, Chemist.
S	1 Set.	Stewart Iron Co., Sharon, Pa., E. R. Sanborn, Chemist.
T	1 Set.	Superior Charcoal Iron Co., Detroit, Mich., W. P. Putnam, Chemist.

of time and money to obtain these analyses and it is to be hoped that the end sought by this paper will lead all the contributors to feel that their labors have been devoted to a good cause.

Considering that drillings were taken from pig metal, which are not as good for checking purposes as those taken from a clean, especially prepared and solid casting, and that there is no uniformity of method in analyses at the present time, the close results seen in Tables 1, 2 and 3 are very creditable to the various chemists and demonstrate that great care was exercised by all. In justice to the donors of these analyses, it is to be said that the analyses given by the respective firms and chemists may not represent half of their work, as checks were run on the analyses reported to make sure no error had been made. To illustrate what is meant by "checks" the last two analyses of each table are cited, which are Dr. Moldenke's checkings. This is, of course, more exacting practice than is generally carried on in the daily routine work of furnace laboratories. For this reason, a much greater variation in the analysis of pig iron as it leaves the furnace yard for the foundry may be expected than is shown by Tables 1, 2 and 3.

The first suggestion that will come to the practical furnaceman and founder in studying Tables 1, 2 and 3 (which are arranged according to the variations in the silicons), is whether the variations found in the analyses of the respective pig metals are sufficient to have any serious effect on their comparative value, when applied to making mixtures of iron. To aid in seeing clearly what are the greatest variations to be found in the analyses shown, attention is called to the last line of each table. In Table 1 there is an actual difference of .27 for silicon, .0155 for sulphur, .114 for phosphorus, .23 for manganese and 1.09 for the total carbon. Table 2 shows a variation of .32 for silicon, .018 for sulphur, .031 for phosphorus, .36 for manganese and 1.04 for total carbon. Table 3 shows .21 for silicon, .020 for sulphur, .067 for phosphorus, .22 for manganese and .30 for total carbon. When such a difference is to be found in analyzing pig metal where the greatest care and skill has been exercised as exhibited

in Tables 1, 2 and 3, what are the chances to be run in accepting analyses made by the different rapid methods in the rush of every-day furnace practice? Here we have, with the best of care and skill, a variation in the ingredients, mainly due to a lack of uniformity in laboratory methods and of a standard for analyses sufficient to affect two-thirds of all the castings made, causing them to be either bad, or ill-suited for the use for which they were intended.

Is it not time that furnacemen and foundrymen were awakening to the necessity of co-operating to secure greater uniformity in the methods of making chemical analyses and in establishing a central standardizing agency?

The writer holds a description of several of the methods used for obtaining the analyses shown in the tables and chemists who have seen them could outline their reasons for giving different results. As the writer is not a chemist, he does not assume to discuss anything regarding their work. Some good work is now being done in this line by a committee headed by the eminent Dr. C. B. Dudley. It is to be hoped that the near future may see such a co-operative agency as that referred to, so that it may be patronized by all chemists employed in the manufacture or use of cast iron.

On opening the discussion Mr. West explained that many chemists had wholly misunderstood the intention of the paper, which had not been to criticise any particular method of analysis, but to show what variations could result in employing different methods, in the rapid every-day workings of a laboratory, even in the hands of able and careful chemists, unless there be some system of checking the findings of the method used.

Dr. Richard Moldenke contributed the following to the discussion: "No set of analyses of pig iron has ever come under my notice which shows so plainly the need of greater uniformity in this class of work. What is the value of this investigation to the foundryman who makes use of chemical methods for mixing his irons? It shows him that he is not always obtaining what he asks for, and furthermore that this may be the case without any

attempt on the part of the furnace to be a little lax in the interpretation of the pig iron specifications. The principal causes of these wide differences in results on the part of supposedly expert chemists are three-fold:—The sample, the method, and the man. First-class chemicals obtained through first-class houses seldom give trouble in the laboratory. So far as the man is concerned in this series of tests, this point can be dismissed without further comment, as all knew what was required and without question did their best.

"The sample is another matter. The three samples I received contained a gritty material, which did not surprise me, as all samples of pig iron run that way. Even when separation is affected with a magnet, there will remain in the iron a certain quantity of mechanically mixed slag which is visible only under the microscope. The first thing every chemist does with samples of pig iron is to clean them with the aid of the magnet. The following shows what came from my samples:

Pig Iron.	Residue in Sample.	Silica in Sample.
Foundry iron	0.29%	0.025%
Charcoal iron	0.07%	0.012%
Bessemer iron	0.21%	0.054%

"The greater part of this residue was evidently scale and not sand. At any rate, only the Bessemer iron would be affected seriously, the charcoal iron being practically clean. This residue, so far as my samples are concerned, will not account for the great variation in the silicons, and certainly not in the other items of the tables, with the exception of the graphites, in the case of which every one acquainted with the constitution of cast iron will at once be prepared for a wide diversity of results.

"To my mind it is entirely a question of method, and here we are face to face with a difficulty experienced by all chemists. The national and international committees have not yet agreed upon standard methods, but as this is fairly on the way, all attempts at establishing laboratories to adjust this matter are uncalled for, in fact detrimental. But we have the example of the Pennsyl-

vania Railroad which issues definite, and, by the way, excellent methods of chemical analysis by which its own purchases are tested. Whoever wishes to supply this company will find it advantageous to carry out his tests by these methods, and thus avoid possible rejection on account of differences similar to those Mr. West has shown to exist.

"The natural inference would be, after obtaining uniform and clean samples of iron, to send them out with their analyses and printed methods. It is to be understood that such samples are not to be used as standards are in steel analysis, but simply as material for the chemist to work upon to check the accuracy of his manipulation. He should, therefore, use the method given, whatever other one he finds most convenient for his daily work. When the time comes for the promulgation of standard methods, the question will be settled definitely.

"The next point to be considered is, what should be the attitude of the foundrymen's associations to the question propounded by Mr. West? To my mind the use of chemical methods of mixing irons in foundries has come to stay, and eventually nine-tenths of the work will be done, not by educated chemists, but by analysts trained from the ranks. I have in mind as I write two successful cases of this kind in small foundries connected with large works. In view of this Mr. West's idea should receive our close attention. It would seem unwise to commit the American Foundrymen's Association to the establishment of a central laboratory, but it could readily lend its influence and if necessary its assistance, to some well-known private institution of good repute, which could undertake the preparation and distribution of the proper material, checked by such chemists as Booth, Garret, and Blair. There would be no difficulty in carrying this out, and with this in view I can heartily second Mr. West's efforts in obtaining something of value not only to foundrymen, but also to chemists, from the remarkable series of analyses he has published."

Messrs. Frank, Scott, Uehling and Kreutzpointer also participated in the discussion. It was the sense of the association that

the subject should be carried to the meeting of the American Foundrymen's Association at Cincinnati, and on motion, President Taylor appointed Messrs. West and Frank and Dr. Moldenke as a committee for this purpose.

Mr. Seaman and Mr. Frank suggested that the matter of Pittsburg representation at the Cincinnati meeting of the American Foundrymen's Association be entrusted to a committee of three, who, beside working for a large delegation should also secure rates and report at the May meeting. The chair appointed Wm. Yagle, Phillip Mathes and J. R. Mills, Jr.

A REVIEW OF THE FOUNDRY LITERATURE OF THE MONTH.

MACHINERY.

Mr. Thos. D. West contributes an article on the "Comparative Value of Test Bars" to the April issue, in which he criticises some of the theories advanced by Herbert E. Field on this subject in the February issue of "Machinery." (Mr. Field's article will be found in the February Journal.) Mr. West says:

The very interesting article on the value of test bars and their relation to casting, which appears in the February number of Machinery, by Mr. Herbert E. Field, contains much that requires straightening out. First of all he says "It has always appeared to me that this controversy over the merits and demerits of the ½-inch square bar and the 1-inch square or round bar has been an instance of the one stopping his ears while the other talks, and vice versa."

The closing of ears cannot be charged to advocates of one inch or larger bars, but to those laboring to maintain the use of ½-inch square bars, nothing has appeared that is more fitting to express the stupidity with which ears have been closed to facts demonstrating the impracticability of trying to use bars as small as half an inch square to make tests of the comparative strength of cast iron. If any desire proof to sustain this statement the writer can give it to them.

Mr. Field's comments on the advisability of measuring and taking note of the least variation in the area of bars at their point of fracture are well made. This is a feature which the writer has advocated for practice in all cases where accurate tests are to be made. It is desirable from the fact that, as Mr. Field states, no two bars can be cast from the one pattern that will measure alike in area at their points of fracture. In some cases bars may very easily differ in diameter or the square, from one-eighth to one-quarter of an inch, from others that have been molded from the same pattern. When we consider that even

the slight difference of one-sixteenth of an inch in the cross section of a bar, when reduced to strength per square inch, can make a difference of from 200 to 400 pounds or more, the importance of taking note of the least difference in the area of test bars, molded from the same pattern, should be evident to all. In cases where the best work is not exacted in securing strength records, several bars may often be averaged to render comparisons. Where it is not possible to take the average of several bars, and one is to be relied on for furnishing the comparison, then in most cases it is very desirable that note be taken of the least difference which may exist in their areas, from the area of the pattern from which they were made.

As to the value of tensile tests, the writer would strongly support Mr. Field's views, and admires the point he makes on all rectangular bars developing marked weakness lines in cooling, which, of course, is an endorsement of round forms of test bars, which present the most uniform texture or grain throughout the area of a test specimen. While the tensile test is a valuable one, the writer would not go to the length Mr. Field has in implying it was superior to transverse tests. It is true many have wholly ignored tensile tests and advocated the transverse test as being the one most suitable for testing cast iron, but this the writer does not indorse. The tensile test has its place as well as the transverse, and the writer often likes to carry both together, for, as a rule, one can be a check upon the other to assist in establishing confidence in the records obtained.

That part of Mr. Field's article under the head of "Test Bars vs. Castings," the writer considers as not being a practical treatment of the subject. The first point to be criticised is that where he starts off with saying that "the tendency of to-day is to aim to get iron test bars strong, regardless of the other qualities of iron which go to make up the perfect casting." If founders accepted this as a rule to work by in making mixtures of iron, over half of the castings desired to-day would be impractical of construction. There are no two different classes of castings but that require a different grade of iron. One may permit of the strong-

est iron to make the casting durable under its work or usage, while the other might give the greater service if made of a weaker iron. The first thing to learn is the grade of iron that is best for your special casting. When this is known you are then in a position to establish the best standard for strength in that particular work, but such a standard is not of the kind Mr. Field suggests in his lines which read, "The first, and it is preferable when possible, is to take a test out of some representative casting which has been rejected on account of a defect." How is any one to know if the iron in such a first rejected casting is the best for that special work? Castings which have never been used or put to the test of actual work, cannot best establish any record to demonstrate that the grade of iron comprising it is the best kind of iron for that special make of casting. It is to be understood, of course, that this refers to castings of which others of the same kind have never been tested to furnish records whereby comparison of its iron could be made in order to know what physical or chemical qualities the rejected casting might have possessed. If Mr. Field had said to take a test bar out of any casting that had given good service, and after testing it analyze it chemically, he would have hit the mark.

It is true, as Mr. Field implies, that in this day of strong competition it is very desirable to have castings that require machining as soft as practical, so as to save expense in finishing, but the manner in which he refers to castings not requiring high strength should be modified. There are very few castings in which high strength is objectionable. In fact, it is a very desirable quality to have exist wherever it can be combined without injuring the durability of castings. It is for this reason that we see pride taken by conscientious founders to obtain as high strength in their specialties as conditions will permit. To tell if with strength we are also obtaining softness is where the transverse tests have an advantage over the tensile tests, as through the transverse tests we are able to obtain a knowledge of the softness of iron. For this reason all published accounts of strength records should be accompanied with that of deflection. Wherever we find these

two combined we can then form very fair opinions as to how much of the softening qualities have been sacrificed to secure the boasted high strength which Mr. Field refers to, and which, as a rule, founders are justified in laboring to obtain, notwithstanding Mr. Field's claim to the contrary. Did many buyers of machinery but know it, they ofttimes accept castings so "soft rotten" that the least unintended jar or shock will cause them to crack or go to pieces in a manner to hazard life or property.

Continuing, Mr. Field says, "The second method is to cast a test in the casting of such shape and in such a position as will best give the true strength of the casting." "This is the only method that can be used when the strength of a specific casting is desired." If Mr. Field desires to obtain the strength of a specific casting, there is but one way, and that is to subject that particular casting to actual usage, or to an appropriate test, which might include hydraulic pressure or that of a drop weight falling on the casting, after the plan used with testing car wheels. The varying proportions of castings and the difference which exists in the ratio of their parts cooling off, combined with the possibility of the existence of sand, blow and shrink holes, are several of the qualities that go to make it impractical to cast test pieces with castings as suggested by Mr. Field to truly define their strength. All that the founder can do in making castings to permit judging of their strength (if not tested by hydraulic or the drop, as cited above), is to make test specimens that will be cast out of the same iron with which the casting is poured, to give him a knowledge of the physical qualities of the iron that goes into the casting. After a casting has demonstrated its durability by usage, then by referring to the mixture used, the founder is best enabled to duplicate a like durability in a like casting, and this is where the utility of the test bars comes in, as it permits making a comparison between two mixtures, to learn whether or not there exists any physical difference in them. By the adoption of such a standard test bar to guide him, he is then best assured that if he can duplicate a mixture that has proven good by use in some specific casting of the past that any further casting made from

the same pattern and mixture is most liable to withstand a similar usage.

A test speciment of the form and size to be the least affected by any variation in the nature or dampness of sand, also by variations in the degree of the metal's fluidity, can be used for a standard comparison, whether made with the casting or poured separate with the same iron after the manner usually adopted in the casting of test bars. This is not saying that when test specimens are made with a casting, as suggested by Mr. Field, that they will define the specific strength of that special casting. Their utility lies in their fitness for making a comparison with records of mixtures that may have been previously used as implied above. Before a comparison can be made to permit our judging of what physical qualities may exist in a specific casting, two or more of such castings must have been previously made at different "heats" and tested as cited above, a study of which quality should clearly define wherein Mr. Field has failed to comprehend the true utility of the test bar, and is wrong in claiming that the only method to obtain the strength of a specific casting is to rely on the records secured from a test piece cast in the same mold with the specific casting, regardless of there having been any previous tests recorded of a similar mixture (as implied by Mr. Field's article), whereby comparisons could be made.

There are so many places in Mr. Field's paper that show that he has failed to grasp the true utility of test bars, one is at a loss what passage to select. Further on he says "That the plea for a universal uniform test bar is an absurd proposition," and says, "The one fact that it is possible to pour from one ladle of good iron a series of tests which shall vary from 15,000 to 27,000 pounds tensile strength should show this." To prove this he asks all to make test pieces of varying sizes, which he means shall be poured from the same ladle and reduced to strength per square inch. Any founder of experience in heavy work shows that if different sections or sizes of test bars are used varying results in strength, etc., records are to be expected, partly because the state of the combined carbon cannot be alike in two bars of

different section or area, due to the variation in the thicknesses of their bodies causing one to cool faster than the other. This is no argument to be used against the adoption of a universal system of tests and is an impractical solution of the problem, and goes to show that instead of Mr. Field accusing others of not having thought deeply, as stated in his last paragraph, he should accept the censure for himself.

R. Moldenke, also referring to the article written by Mr. Field, says:

"In the article of Mr. Field on test bars and their relation to the strength of castings, appearing in your February number, a statement is attributed to me which I cannot recollect having made. Only two articles on this subject have appeared from my pen, and in neither of them do I find myself advocating the 'impossible and absurd' proposition of a universal test bar.

"On the contrary, what is wanted is a universal system of test bars which will cover all the cases met with in the various products of cast iron.

"Mr. Field's whole article is a very able plea for such a system. The series of apparent contradictions in the behavior of cast iron test samples he brings out are perfectly familiar to foundrymen, and it is gradually bringing them to the conclusion that more and deeper study is necessary before a judgment of any kind can be formed. Thus, if Mr. Field had grasped the situation properly, based as it must be upon the recognition of cast iron as a mineral in its constitution, he would not have advocated the tensile test so warmly, without surrounding it with a very considerable number of safeguards, and giving very definite specifications as to the shape and manner of testing the samples supposed to represent the castings.

"The well-known fact that test bars can be manipulated to show almost anything desired, only emphasizes the necessity of definite specifications to cover definite classes of work; which is the proposition I am advocating, and not what Mr. Field attributes to me."

IRON AGE.

Writing of the "Need of Greater Uniformity in Pig Iron Analyses," and referring to the paper read by Mr. West under the same title before the Pittsburg Foundrymen's Association, Mr. Albert Ladd Colby says in the issue of April 21:

"Mr. West, in speaking of the recent introduction of chemistry in founding, states that 'there is still a prejudice with many against chemical analysis as a determiner of grades or as a basis for making mixtures.' He states that 'the thing to do is to determine the factors that tend to prevent the general use of chemical analyses and work to correct what needs correcting.' He 'knows from experience some agencies that retard the general utilization of chemical analyses in making mixtures.' He mentions the personal factor, due to a change of chemists at the furnace supplying the founder or to the purchase of iron from another furnace, either of which, he states, may destroy the comparative results of past practice in making mixtures from furnace analyses. He states that the strength and purity of chemicals used is an important factor, and explains that variations from this source are guarded against by testing chemicals when received and rejecting those found to be impure. The third cause of error attributes to the variation due to the analytical methods used and states that it is a common practice to determine this variation by averaging the results obtained by four or more chemists of known ability and accuracy on the same sample of clean, fine, well mixed drillings. He speaks of the labor and expense attending this method of checking and urges the establishment of "a central laboratory where all chemists dealing with cast iron could obtain standardized drillings promptly and at a price comparatively small.'

"In response to an appeal made by Mr. West at the meeting of the association held November 22, 1897, and in letters subsequently addressed by him to the various iron companies, he obtained replies from 20 chemists offering to analyze drillings of pig irons to be prepared and distributed by him, with the avowed object of determining the differences due to analytical methods.

His paper includes three tables, one comparing the analyses of 13 chemists on the same sample of Bessemer iron, another of 16 chemists' results on a foundry iron, and the third including 11 chemists' results on a sample of charcoal iron. The chemists do not, however, report complete analyses in all cases. The following summary of the three tables shows the highest and lowest percentages reported, with the variation between these extremes. An average percentage is purposely not included, as the writer considers it of no value in such widely varying results:

Constituents	determined.	Bessemer.	Foundry.	Charcoal.
	Highest per cent	2.445	2.228	1.161
Silicon	Lowest per cent	2.12	1.95	0.95
	Variation per cent	0.325	0.278	0.211
	Highest per cent	0.066	0.020	0.033
Sulphur	Lowest per cent	0.048	0.0045	0.013
	Variation per cent	0.018	0.0155	0.020
	Highest per cent	0.111	0.617	0.957
Phosphorus	Lowest per cent	0.080	0.503	0.89
	Variation per cent	0.031	0.114	0.067
	Highest per cent	1.09	0.69	1.98
Manganese	Lowest per cent	0.73	0.46	1.76
	Variation per cent	0.36	0.23	0.22
	Highest per cent	4.35	4.27	3.98
Total carbon	Lowest per cent	3.31	3.18	3.17
	Variation per cent	1.04	1.09	0.81
	Highest per cent	3.51	3.59	3.30
Graphitic carbon	Lowest per cent	2.78	2.82	2.69
	Variation per cent	0.73	0.77	0.61
	Highest per cent	0.85	0.82	1.02
Combined carbon	Lowest per cent	0.25	0.23	0.44
	Variation per cent	0.60	0.59	0.58

"In another table Mr. West gives the names of the 20 firms and chemists, and in tendering his thanks to them for so kindly furnishing the analyses he states that 'the close results seen in tables 1, 2 and 3 are very creditable to the various chemists and demonstrate that great care was exercised by all." This opinion, evidently tempered by his feeling of obligation, is offset by him further on in the paper, for when using the results as an argument in favor of his plan for a central standardizing laboratory he states: 'When such a difference is to be found in analyzing pig metal where the greatest care and skill has been exercised, as exhibited in tables 1, 2 and 3, what are the chances to be run in accepting analyses made by the different rapid methods in the rush of every day furnace practice? Here we have, with the best of care and skill, a variation in the ingredients, mainly due to a

lack of uniformity in laboratory methods and of a standard for analyses, sufficient to affect two-thirds of all the castings made, causing them to be either bad or ill suited for the use for which they were intended.'

"The writer, who was one of the 20 chemists included in Mr. West's distribution of samples, is conndent that he expresses the opinion of his associates in stating that without exception the wide variations in each of the seven constituents in all three samples are very far from being 'creditable to the various chemists,' and he is equally sure of their support in asserting that if more care had been exercised by Mr. West in preparing his samples the chemists' analyses would not have been so widely discordant.

"The writer fears that in the author s anxiety to prove the necessity of a central standardizing agency he has fallen into the oft used expedient of first making a man of straw and then attacking him, for with the co-existence of two variables discordant results cannot logically be attributed to one cause.

"Last November, when Mr. West first ppresented his plan to the Pittsburg Foundrymen's Association, he stated that the results of various chemists' analyses of the same sample would determine 'to what degree analyses may differ,' and he expressed the hope that the results might further 'the general adoption of some one system of chemical analysis of pig iron.' A standard method of analysis was, therefore, clearly the object he had in mind. Hence every possible precaution should have been taken by him to furnish each chemist with uniform samples so as to eliminate a frequent source of error and enable the subsequent discussion of the results to be based entirely on the variation due to the analytical methods adopted.

"Before the company with which the writer is connected offered to accept samples for analysis a letter was written to Mr. West asking what precaution had been taken to insure the distribution of uniform samples, to which the reply was received that the samples had been in no wise prepared other than to thoroughly mix a large quantity of drillings from each of the

three pigs and that the samples were distributed 'with the request that each one receiving samples remove any sand that might be found in them.' It was further stated that 'the idea is not so much to test the extreme thoroughness which any of the laboratories are capable of displaying as it is merely to receive a report from them in the ordinary way such as they would give to one of their customers.' On receiving this discouraging reply the writer offered to analyze but one of the three samples, the drillings from the Bessemer pig iron. The sample did contain sand, which was, according to instructions, removed as far as possible. The following statement shows that the drillings received were so irregular in size that check determinations of the praphitic carbon on 20 such samples from a large lot of drillings would be an utter impossibility.

		Per cent.
Portion remaining on 20-mesh sieve	11.3081 grams =	8.95
Portion between 20 and 40-mesh sieve	33.3330 grams =	26.36
Portion between 40 and 80-mesh sieve	36.8060 grams =	29.11
Portion finer than 80-mesh sieve	44.9875 grams =	35.58
	126.4346 grams =	100.00

"In support of this criticism the writer submits the result of an experiment made by him several years ago when studying the question of sampling pig iron:

Portion remaining on 20-mesh sieve	2.090 per cent. graphite
Portion between 20 and 40-mesh sieve	2.010 per cent. graphite
Portion between 40 and 80-mesh sieve	1.912 per cent. graphite
Portion finer than 80-mesh sieve	2.684 per cent. graphite

"A comparison of the various chemists' results on Mr. West's sample of Bessemer pig iron, omitting the carbon determinations, is printed on following page.

"In his paper to be discussed on the 25th inst., Mr. West gives the following description of the method used in preparing the samples: 'Here are three pieces of pig about 9 inches long, having ¾-inch holes drilled about 2½ inches deep from the face down and as close as they could be obtained. The drillings from these samples of foundry, Bessemer and charcoal pigs respectively were kept separate and those for each pig thoroughly

mixed, so as to insure that all samples sent out were exactly alike as far as it was possible to get them by the use of pig metal. Pig iron was selected in place of making any special castings, so as to test particularly the ordinary practice followed at blast furnaces in taking drillings from pig metal.' This he follows with the confession that 'drillings taken from pig metal are not as good for checking purposes as those taken from a clean, especially prepared and solid casting.'

Laboratory of—	Silicon.	Sulphur.	Phos.	Mang.
Buffalo Furnace Company, Buffalo, N. Y., Frank Hersh, chemist	2.12	0.060	0.088	0.73
Tennessee C., I. & R. R. Company, Birmingham, Ala., J. R. Harris, chemist	2.15	0.048	0.094	0.93
Embreville Iron Company, Embreville, Tenn., F. E. Thompson, chemist	2.20	0.056	0.086	0.91
Illinois Steel Company, South Chicago, Ill	2.21	0.051	0.093	0.95
Stewart Iron Company, Sharon, Pa., E. R. Sanborn, chemist	2.25	0.058	0.090	0.90
Phillips Testing Laboratory, Birmingham, Ala	2.29	0.048	0.080	1.09
Claire Furnace Company, Sharpsville, Pa., D. K. Smith, chemist	2.30	0.051	0.087	0.910
Carnegie Steel Company, Cochran, Pa., T. M. Camp, chemist	2.31	0.056	0.083	0.89
Crane Iron Company, Catasauqua, Pa., H. A. Knauss, chemist	2.31	0.060	0.0865	0.890
Andrews & Hitchcock Iron Co., Youngstown, Ohio	2.32	0.051	0.086	0.84
Hamilton Furnace Company, Hamilton, Ontario	2.32	0.055	0.111	0.809
The Bethlehem Iron Company, South Bethlehem, Pa., A. L. Colby, metallurgical engineer	2.37	0.058	0.087	0.83
Dr. R. Moldenke, metallurgical engineer, Pittsburgh, Pa	2.445	0.064	0.086	0.93
Dr. R. Moldenke, metallurgical engineer, Pittsburgh, Pa	2.402	0.066	0.084	0.98
Dr. R. Moldenke, metallurgical engineer, Pittsburgh, Pa	2.413	0.060	0.086	0.96
Greatest variation	0.325	0.018	0.031	0.36

"The writer, acting as spokesman for the 20 chemists whose discordant results on the three samples will but serve to further prejudice the practical foundryman whom Mr. West wishes to win over to science, and for the many other iron and steel chemists who have often been unjustly criticised for analytical differences due to ignorant sampling, appeals to the furnacemen and foundrymen for co-operation with the chemists, not to secure

uniformity in the methods of making chemical analyses—for there are several equally accurate methods available, and this field properly belongs to a committee of chemists—but to co-operate with the chemists to secure greater uniformity in methods of sampling, a source of error which now constitutes as important a factor in retarding the general utilization of chemical analyses in making foundry mixtures as the three factors mentioned by Mr. West.

"Let the furnaceman make his chemist responsible for the accuracy of the sampling as well as for the accuracy of his analyses. Give him authority to outline the method of sampling each cast of pig iron, not simply have some one take one pig from each cast to the machine shop to be drilled. Give him the further authority to instruct the machinist as to the location and size of the hole to be drilled and the character of the drillings which must be sent to the laboratory, and when such a system is established let him require from his chemist analytical evidence that his method of sampling is representative.

"Compare the variation in silicon and sulphur in the following analyses of the different beds of a cast of pig iron with even the wide variations in the chemists' results reported by Mr. West and the importance of representative sampling is at once apparent. This is not an exaggerated instance selected from the writer's 12 years' experience in iron and steel metallurgy. Let any furnaceman who doubts it give his chemist an opportunity to repeat the experiment:

Central pig from—	Silicon.	Sulphur.	Phosphorus.	Manganese.
First bed cast	1.93	0.029	0.084	0.37
Second bed cast	1.26	0.052	0.084	0.31
Third bed cast	1.15	0.049	0.084	0.32
Fourth bed cast	1.16	0.051	0.083	0.32
Fifth bed cast	1.28	0.056	0.082	0.32
Sixth bed cast	1.28	0.044	0.084	0.31
Seventh bed cast	1.43	0.033	0.084	0.32
Eighth bed cast	1.26	0.049	0.085	0.31
Ninth bed cast	1.26	0.046	0.084	0.30
Tenth bed cast	1.05	0.065	0.084	0.31
Eleventh bed cast	1.05	0.055	0.084	0.30
Twelfth bed cast	1.23	0.055	0.084	0.31
Greatest variation	0.88	0.036	0.003	0.07

"The purchaser of the foundry pig iron also has it in his power to bring about the two reforms (more representative sampling and more accurate chemical work) necessary to increase the value and extend the adoption of chemical analysis as an aid in his foundry mixtures. Even without a chemist at the foundry to analyze the pig iron he purchases the foundryman can obtain from furnacemen chemical analyses truly representative of the iron he uses, for in these days of close competition and overproduction he has but to definitely specify that he will not purchase iron unless properly sampled for analysis to bring about prompt radical reforms among the producers; and having gained this point let him next demand a sealed portion of the samples analyzed by the furnace chemist, with the understanding that the expense of the check analysis by a mutually satisfactory independent chemist shall be borne by the seller if the furnace chemist's results are found to be erroneous. The payment by the furnacemen of a few such bills, at $4 for each determination, will lessen the number of alleged furnace chemists, whose careless and inaccurate work is responsible for much of the existing prejudice against the profession, and who could never be made into accurate chemists by the existence of either standardized drillings or standard methods of analysis.

"Although in this criticism the writer has entered a protest against publishing comparisons of different chemists' analyses made on ununiform samples, and has urged furnacemen and foundrymen to aid chemists in securing the careful sampling of pig iron, without which accurate chemical work is wasted, he is too keenly alive to the chemist's own shortcomings to adversely criticise any practical suggestion tending to aid the chemist in the improvement of his analytical methods, and he heartily indorses Mr. West's idea of establishing a cheap supply of standardized drillings or turnings of pig iron. Such a plan need not, however, include the expense of installing and 'maintaining a central laboratory,' for the work could be undertaken as an adjunct in some laboratory where it is sure to receive careful attention.

"Mr. West will recommend that the iron to be used for standards be cast in hollow cylinders. This the writer indorses and in addition suggests limiting their size, so as to further avoid the irregularities in composition due to segregation; also that preliminary analyses be made to determine whether this has been successfully accomplished before the casting is set aside to be used as a standard, and finally that no pains be spared to obtain fine, uniformly sized turnings.

"In the selection of the analytical methods by which the samples shall be standardized it would be advisable to consult the International Committee on Standard Methods for Iron and Steel Analysis, who were appointed in response to the suggestion made by Prof. J. W. Langley in 1888, and at least two of the American members of this committee should be asked to check the analytical work. Each sample should be analyzed by six chemists.

"The national Foundrymen's Association would do well to also subscribe to the fund for the International Laboratory for the Chemistry of Iron proposed by Professor Wedding in August, 1897, at the International Congress for the Unification of Methods of Testing. 'This laboratory will aim to compare and fix the degree of accuracy in the analytical methods employed and to specify those which are worthy of recommendation in cases of controversy, whether for exact assays in technical laboratories or for daily controlling the manufacture.' Thanks to the generosity of the Swiss government, a suitably equipped building has been provided, and the salaries of the officers have been partially covered by voluntary subscriptions promised for ten years by the leading iron works. Although the sums promised are not yet sufficient to carry out the programme in its entirety a start has already been made.

"In a subsequent article the writer proposes to describe the different methods of sampling pig iron, including the sources of error and the precautions necessary to adopt to secure representative samples, and he hopes his suggestions will be read by the furnacemen and foundrymen to whom he has appealed for aid

in securing greater unifrmity in methods of sampling, thus giving practical value to accurate chemical work and removing the obstacles that retard the more general adoption of chemical analyses as a basis of foundry mixtures.

Replying to the letter of Mr. Colby, Mr. West says in the issue of April 28:

"The criticisms made by A. L. Colby in your issue of 21st on the writer's paper, 'The Need of Greater Uniformity in Pig Iron Analyses,' ascribes the variations shown to imperfect sampling of drillings. The purpose of the writer's research in this field was not to find what would be obtained from especially prepared drillings, such as he implied should be secured for standardizing purposes in his letter to Mr. Colby, but to obtain knowledge of what variation at the hands of able and careful chemists different methods and chemicals used in the every day practice of rapid working laboratories would render of analyses secured from ordinary pig drillings. This is what guides our operations in a commercial way, and is the condition existing which we must meet in the actual operations of purchasing and mixing pig metals in working by chemical analyses.

"The furnaceman in selling his iron may have to ship it over one to four or more States before it reaches its user's yard. In order to check the furnace analyses, the distant purchaser has but one recourse, and that is to select and drill samples of the pigs contained in the car or pile delivered from it. If the analyses of these drillings are seriously off from the furnace's report, the latter, if called to account, may often ask for a sample of the drillings used, to check the former's results, and which is one incident to illustrate the trouble which difference in methods may cause all concerned. It was largely the results of such general practice that the writer desired exhibited in the paper Mr. Colby has criticised. There is no question but what less variation would have been shown had the drillings been prepared after the manner Mr. Colby desired, but such is not the treatment pig drillings receive at the hands of the furnaceman or founder in

making analyses of them in the every-day practice of laboratories. Pig drillings are more or less liable to contain some sand or grit, which, as a rule, careful chemists remove by a magnet before the drillings are analyzed. Little or no attention is paid to grading such drillings to a uniform size, but they are used just as they come from the drill press in respect to their uniformity. This was the plan adopted by the writer, as he desired to follow the general practice as far as could be done, for any other course would not have given us knowledge of the reports varying methods would render in actual practice at the hands of able and careful chemists, and who, in many cases, in the rush of business are confined in a sweat box and often expected to make from 25 to 30 determinations per day.

"The writer cannot agree with Mr. Colby's views in claiming that the variations shown are due to the character of sampling the drillings, and to sustain his position he would kindly call attention to the fact that where a chemist is low in silicon with one class of iron, he is, as a rule, low or not far away in the other two, or vice versa, in regard to being high, as exhibited by tables 1, 2 and 3. As an example of such checkings, see laboratories A and P, the first and last of the three tables. It was partly for the purpose of affording an opportunity to display the results of methods checking themselves that the writer gave drillings of the three different classes of iron, and he believes a study of this feature will greatly modify the stress Mr. Colby lays on imperfect sampling as the cause of the variation shown. To illustrate cases of bad sampling, Mr. Colby cites the difference which may exist in the two ends of a furnace cast of pigs as being 0.88 in silicon. This is true, and can at times exceed this figure, but the writer fails to perceive wherein such illustration has any relation to his sampling of drillings. The pigs from such a furnace cast to obtain the variations in silicon cited could range, if placed end to end, 1,500 to 3,000 feet in length, whereas what the writer used was a piece of pig but nine inches long, and by reason of its short length must necessarily affect the closest uniformity of the metalloids in the drillings sent out to the various chemists. Mr.

Colby's criticisms of the writer's paper would tend to lead a reader to believe that there was very little or no difference in the methods used by chemists over our broad land, or that perfection had been attained in establishing uniform methods.

"The writer is pleased to note that Mr. Colby indorses his plan of having a central standardizing laboratory or agency where any could obtain drillings standardized by competent chemists at a nominal price. The establishing of such an agency would, in the writer's estimation, do more toward establishing uniform methods in six months than could be done otherwise in about so many years. The simple factor of the manager of a laboratory, furnace or foundry being able to hand a chemist a standardized sample of drillings (unknown to the chemist as being such) to have him analyze it together with any other set of drillings that might have to be determined to settle a dispute or guide aright the making of mixtures, is in itself a medium to test the correctness of methods, chemicals and analyses that is little dreamed of to-day."

THE METAL WORKER.

Thos. F. Kennedy evidently believes that a molder will turn out more work if he is permitted to assume a natural position while working, a conclusion that ought to be more generally accepted. In a recent article he says:

"Can any one name a single body of workers in any field of human activity who stoop to do work when it can be avoided except molders? I could fill this page with a list of trades and arts where there is better reason for stooping to do the work than there is in molding small stove work, and yet means have been found to avoid it. How many molders does the reader know who are suffering from lame backs brought on by stooping?

"It is a fact that all molders will testify to that small work, no matter how arranged, is much harder on the back than large work. It is a common thing to hear a molder say, 'I don't mind the large work, but the small work is killing.' And there are

plenty of molders who can do a good day's work on large work who could not stand to take small pieces on the floor, though the large work requires far more exertion than the other. A molder making small pieces on the floor must maintain a stooping posture of varying degrees all the time while molding, excepting the short time while ramming, and all don't straighten up then. The molding time varies from six and a half to eight hours. A man of average height must work more than one-half of this time bent over to an angle of 90 degrees, and I have seen men making work which required great care in finishing who had weak sight, or, having strong sight in poor light, bent over at an angle of 50 or 60 degrees doing the most particular part of their work. Did the reader ever notice the small percentage of old and elderly men engaged in stove molding—smaller than in any other occupation of which I have any knowledge? There are plenty of molders shortening their lives working on small stove work on the floor who have recurrent attacks of lame back and sore chest. These often become chronic, and they are obliged to give up. A very large percentage of these defects would never develop sufficiently to cause inconvenience under normal conditions where a man could stand up straight, or nearly so, all the time.

"No wonder statistics collected a few years ago showed that the average length of time spent at the trade by those learning it was fifteen years. The first impulse of a young man or boy when he starts to learn the molding trade is to avoid stooping by kneeling down, but the foreman or instructor will quickly tell him that he will never make a molder if he kneels down to any of his work. Jobbing and machinery molders do kneel sometimes, but I know of but one stove foundry where it is a common practice, and there the follow boards are very poor. It is related of the workers in an industry where the large quantities of dust and fumes were a constant menace to health that when a device was invented which promised to nullify their evil effects its use was secretly opposed by the workers on the ground that its introduction and successful use would surely cause a reduction in

wages. No doubt this consideration would produce and nourish a hostile sentiment which would cause plenty of floor molders to stand in their own light, and deter them, if they were allowed to choose, from taking advantage of an improvement even though it promised to lessen their ills and lengthen their days.

"In following out the rule laid down for follow boarding, I would eliminate wherever practicable the portion that says one kind of pattern and make it simply one pattern on each board. Any piece which from its size and nature cannot be made in a snap flask, and is too small to be made one in a flask on the floor, will, in nineteen out of every twenty cases, make a good job if made alone on a board in a suitable flask on a properly designed movable bench. It is to be anticipated that objections would be made to any such radical departure from long settled practice. Most of the objections are obvious to the experienced stove man. The molders would, no doubt, for reasons already touched upon, offer numerous trivial objections. The only one I can think of worthy serious consideration is the raising of the sand an additional 15 or 20 inches and the lifting of the finished mold from bench to floor.

"I claim that being able to stand erect 99 per cent of the time trebly compensates for the extra exertion involved in raising the sand and lifting the mold."

THE TRADESMAN.

Under the title "Practice makes Perfect" Mr. Putnam says:

"Perfection is not accomplished by any one man; it is the product of the ages. What we as foundrymen seek to do is to produce castings as nearly perfect as possible within a limit as to cost. System is the most potent factor in the achievement of this result. The more restricted the variety of work required of the mechanic, the better will be his product. In these days of fierce competition, quantity is a word that must never be lost sight of. The first thing is a sufficient quantity of good, merchantable castings. Then, without abating the quantity, the quality must be worked up to the highest possible mark; and

when this point is reached the hard work is only just begun, for any abatement of vigilance will be followed by a corresponding decline in quality.

"I will dismiss the general jobbing foundry from consideration in this article by the remark that highly-skilled workmen and good facilities are indispensable here.

"But the great majority of foundries are engaged in duplicate work. Here the workmen have greatly less general skill but much greater particular skill. It is important in this kind of work that the performer be confined to as few patterns as possible—if to a single one, all the better, for it is obvious that a man can learn to do one thing better than two or more. And it is certain that an apprentice can learn to mold a single piece in a few weeks under proper conditions better, quantity and quality both considered, than the first-rate mechanic can do at the outset.

"I say 'under proper conditions.' This is a part of the statement that must not be lost sight of. I insist upon this very strongly, because, strange as it may seem, there are many foundries where it is entirely ignored. They see castings that were made in some distant foundry, and looking upon them with admiration, they insist that 'we must equal this product.' But they fail; they don't know why. They strive with all their might, but meet with never ending discouragement and defeat. You can't expect to win the race in cowhide boots. The factory where the good castings come from use Albany sand or its equivalent, while 'we' use the cheapest stuff procurable in our vicinity. 'They' spend a large amount of time and money in perfecting patterns that 'we' would think thrown away; and 'we' think this way simply because we are not sufficiently impressed with the fact that a perfect casting cannot be made from an imperfect pattern. And when I speak of perfect patterns I do not mean simply patterns with smooth surfaces and correct draught, for, while this might be sufficient with some patterns, yet it is far short of what is necessary. Take for illustration a pattern weighing, say four ounces. It would be very difficult to get a

perfect pattern of this, especially if of such shape as to require 'rapping' before 'drawing,' because the tools employed are too heavy, nay, the workman's hand is too heavy to properly manipulate so light a pattern. But when such patterns are gated in sufficient number to a correctly proportioned runner the whole card will have sufficient weight and size to enable the workman to manage it with ease.

"In foundries where the highest grade of castings are produced all facilities are brought up to the highest point of excellence and they are thus maintained. In these foundries a foreman's suggestion of an improved facility is gladly welcomed and forthwith produced. But there are many shops where the foreman hardly dares ask to have a broken pattern repaired; and yet his employer wonders why his castings are no better. Perhaps the greatest obstacle to advancement in many foundries is the fact that the ingenuity of the foreman and his men will enable them to produce tolerable castings with the most execrable facilities."

IRON TRADE REVIEW.

Under the caption, "Carbon and Silicon in Pig Iron," Guy R. Johnson refers to the discussion of this subject at the March meeting of the Western Foundrymen's Association. He says:

In the first place, I don't agree with Mr. West, in his statement, that "the carbon should be wholly ignored." As far as the general foundry trade goes, and the general brands of foundry iron are concerned, I quite agree with him; but when it comes to making castings, which have to be of great density and tensile strength, the claim that the carbons can be wholly ignored, does not rest upon a sound basis. For instance, I will submit the analysis of a 19-inch roll just turned out in the foundry of this concern.

Silicon	.75
Sulphur	.10
Phosphorus	.47
Manganese	.33
Graphitic Carbon	2.84
Combined Carbon	.50
Total Carbons	3.34

This roll, which was admirable, as far as good qualities go, being exceedingly tough and dense, contained 80 per cent of iron produced at this furnace, wherein the normal carbons run from 4.10 to 4.25. Does Mr. West think that if the normal carbons had been present, it would have been possible to make so good a roll? If he does, I shall be greatly surprised; the more so, as he is looked upon as an expert in that particular branch of the foundry business.

On the other hand, I don't agree with Mr. Sorge in his claim that "carbon is the most valuable constituent of iron." Of course, as he justly remarks, iron in its cast condition is caused by a combination of iron and carbon; without the carbon, cast iron would not be cast iron. Nevertheless, the one instance that he gives to prove that carbon is the most valuable constituent is not strictly foundry work, in the commonly understood and accepted meaning of the term. Of course, malleable iron casting is a branch of foundry work, yet, I venture to say that when the foundry business is referred to, one naturally thinks of gray iron casting.

The one feature of Mr. Sorge's remarks I fully agree with is, that "the value of high carbon iron in malleable work is caused by the intense heat, which can be generated by the carbon present in pig iron." I would say, in support of this theory, that it has only been a few years since Bessemer iron was considered "off color" if it had less than 2 or 2½ per cent silicon in it, and the generally accepted theory was that the iron in the converter derived most of its heat from the combustion of silicon. Nowadays, Bessemer furnaces are supposed to run from 1 to 1¼ in silicon; in other words, the heat in the converter is obtained from the carbon. Furthermore, this is the opinion of our customers who are using this iron for making malleable castings.

I don't believe, however, that any practical founder will agree with Mr. Sorge in his remark that "the higher the carbon contents of the iron, the greater its fluidity." Every furnaceman knows that No. 1 iron, high in carbon, runs very stiffly, and with the evolution of a great deal of "kish," or graphitic carbon. Ex-

periments carried on at this place would seem to indicate that a medium carbon, with fairly high phosphorus contents, 1 and 1¼ per cent, will give the greatest fluidity. Silicon in such iron should be 1½ to 2 per cent; and this brings me to Major McDowell's remarks:

His proposed table, while it will be of value, no doubt, to the foundryman, would, if accepted, entail an arbitrary standard of values on furnacemen, which would not be in the least just. Take, for instance, the manufacture of chemical castings. This concern has furnished a considerable quantity of iron for such work, and it has been found universally that comparatively low silicon iron—1.30 to 1.50 per cent—with phosphorus, manganese and sulphur within the Major's limits, gives much better results than the higher silicon iron. Now, what the foundryman wants is results. If the furnaceman can give him an iron that will furnish these results, why should he not pay as much for this iron as for the higher silicon iron, which does not possess the properties which he is after. I mention this particularly, because it has come up several times within the last year. It seems to me, in this connection, that Mr. Ferguson's remarks concerning the education of foundrymen cover the ground. If they will tabulate for themselves a series of analyses, which represent the best in each of their lines of castings, and then call for an iron that will possess that analysis, taking into consideration, of course, the changes occurring in the cupola, that would be much the most satisfactory arrangement that could be arrived at. Such a table as suggested by Major McDowell, would give a man making machinery casting, and work of that class, an enormous advantage in price over shops turning out lighter work where higher silicon metal must be used.

On the other hand, the Major's remarks concerning the value of silicon to the average founder are certainly borne out by facts; but what I want to insist upon is that no hard and fast rule of this kind can possibly be employed.

Neither do I quite agree with his remarks concerning sulphur. Sulphur in a limited degree is a most valuable element, acting

as it does very strongly to make combined carbon. I don't believe that its presence in quantities over .12 is ever advantageous, and it is only in exceptional cases that it ought to go so high. But I think that any one who tried to make a roll, either sand or chilled, without calculating on using fairly high sulphur, would very soon want to know "where he was at." Furthermore, I should like to call the Major's attention to one of the most celebrated gun metals in Europe, namely, that produced at Finnspong. There the sulphur habitually runs over one-tenth.

Speaking as the representative of one of the furnaces, which makes and sells iron on guaranteed analysis, I can assure Major McDowell that his idea that "the more confused the foundryman gets, the better the furnaceman likes it," is a mistake. As far as my acquaintance with the trade goes, and it is somewhat extensive, I have yet to meet any one making and selling pig iron on the basis of guaranteed analysis, who is not anxious that foundrymen should tell him exactly what they want. It is much easier to supply a man who knows what he wants, and is willing to pay for it, than it is to furnish iron to the average rule-of-thumb foundryman, who blames everything on pig iron, and never thinks of making an analysis of coke, or of his resultant castings, to see where his trouble really arises. Chemistry will not cure all the troubles attendant upon foundry business, but it certainly will go further towards curing them than any other method so far devised.

While I am on this subject, I want to say a word in regard to the habit a great many foundrymen have—men, too, who employ chemists, and ought to know better—of analyzing one pig out of a car. Now, it all depends on what the furnaceman calls an average sample, as to whether the analysis accompanying a car load is correct or not. Suppose, for instance, that samples for use in the laboratory are taken each two or three beds, as the iron is running, then drilled and mixed in equal proportions; that would as surely give an average analysis of the cast as anything well can, and that is the method pursued by a number of our furnaces. Speaking from personal experience, I can say emphatic-

ally that by using this method in the nearly three years we have been in blast, we have only had two disagreements as to analysis, and in both cases the furnace chemist has proven correct, when drillings were taken from 50 or 60 pigs.

There seems to be a prevailing opinion among a good many of our foundrymen, that furnacemen are more or less of a piratical set, anyhow, and attach too little value to the analyses they send out. I don't believe that this impression is warranted by the facts, for the simple reason that it does not pay a furnaceman, who has regular customers, to run any risks of losing valuable trade, for the sake of getting off of his yard a few casts, all of which are sure to go sooner or later anyhow.

Alex. E. Outerbridge, jr., also referring to the discussion at the March meeting of the Western Foundrymen's Association, says, under the heading "Some Curious Facts Concerning Silicon, Manganese, etc."

The statistics of production of metals and minerals in the United States for 1897 show that this country has forged to the front very rapidly in recent years, so that it now surpasses all other nations in the output of iron, copper, coal, and other so-called "economic" metals and minerals, as well as in production of the precious metals.

The list of economic metals is quite a long one, yet I propose to endeavor to show herein that it is nevertheless incomplete, and that many thousands of tons of certain metals are produced annually in this country which are not noted in any of the official or other published lists. Moreover, I have observed during a long course of years a progressive increase in the annual production of these unclassified metals.

Not wishing to mystify the reader further, I will explain at once that I refer especially to silicon and manganese contained in pig iron. The table of analyses of different grades of pig iron given by Major McDowell in his recent address before the Western Foundrymen's Association, shows that silicon ranges from three per cent in "No. 1" foundry pig iron down to one per cent in "No. 9," or even less. The silicon in "No. 4" is given at 2 to

2.25 per cent, and it may therefore be safe to assume for this calculation that two per cent represents, approximately, the average content of silicon in the pig iron produced in the United States in 1897.

We are informed by Mr. Birkinbine that the output of pig iron in the United States in 1897 amounted to 9,652,680 gross tons. Assuming a sufficient approach to accuracy in the estimate here given of the average content of silicon contained in this pig iron, we find by a very simple calculation that this country produced no less than 193,053 gross tons of silicon in 1897, of which no account is taken in the statistical account of metals and minerals.

Even if we should strike off one-half from our estimate, which would surely reduce it to a minimum allowance for the average content of silicon in the pig iron, we would still have nearly 100,000 tons of silicon produced in 1897, or more tons weight than that of all the gold, silver and several other metals added thereto! The tendency of modern furnace practice is, I think, to increase the percentage of silicon in pig iron since the foundrymen have learned the value of this element as a softener, instead of regarding it as a bugbear as heretofore.

In an address given before the Franklin Institute ten years ago, I called attention to the marked influence of silicon as a softener, and gave there some representative tables of analyses showing the average composition of pig iron, steel and malleable iron. It has been my province, both before and since that time, to make frequent, I may say daily, determinations of silicon in pig iron of various grades from various parts of the country, and of the content of silicon found in castings made therefrom. Ten years ago I still found it necessary to use a considerable proportion of "ferro-silicon" in certain work in order to bring the silicon in the castings up to a certain desired percentage of that element. Of recent years, owing to the gradual increase of silicon in nearly all foundry irons, I have not only found it unnecessary to continue to use a specially high silicon iron in order to accomplish this purpose, but even have been obliged, sometimes, to resort to

special methods to reduce the silicon in the castings to the desired point.

I agree with Major McDowell in his views regarding the value of silicon from a metallurgical standpoint, but I differ from him with respect to the financial point of view. Is it not easier and cheaper for a modern hot-blast furnace using average ores to produce soft gray foundry pig iron containing two per cent of silicon or over, than it is to make soft gray foundry pig iron containing one per cent of silicon or under?

Is it not true, moreover, that any furnace that can guarantee to furnish such soft gray iron low in silicon (less than one per cent), can obtain a higher price for it on that very account? Such iron can be used for car-wheel castings and for other purposes for which ordinary foundry iron, containing two or three per cent of silicon, is not suitable.

With respect to manganese, Major McDowell's table shows a variation from .8 to .4 per cent in different grades of pig iron. Assuming half of one per cent as a fair average, we have (applying our rule) nearly 50,000 tons of manganese produced in 1897, and not accounted for in the statistics.

This element is greatly maligned and misunderstood by foundrymen as a general rule. It behaves very differently under different circumstances, and with different kinds of iron. Experiments made 15 years ago satisfied me that under suitable conditions the effect of manganese added in a ladle of molten metal was to cause a large proportion (nearly one-half) of the combined carbon in pig iron which is low in silicon to revert to the graphitic form. The strength of test bars made from metal so treated was increased from 30 to 40 per cent; the depth of chill was decreased about 25 per cent, and the shrinkage was decreased about as much. These tests were made with car wheel iron, which differs materially of course from ordinary foundry iron.

If this method of calculation shall be applied to the other well known elements in cast iron, viz., carbon, sulphur and phosphorus, it will be found that it will be necessary to add several hundred thousand tons to the tables of mineral products in the

year 1897. Of course, there is a fallacy in this argument which is only here suggested as a curious and perhaps original or novel line of thought. The various elements in pig iron are not isolated, but form an integral part of the metal, and they are collectively, though not individually, accounted for in the total weight of pig iron produced. The point of special significance which such a calculation enables me to elucidate is the fact, not generally known or understood, that the average composition of the pig iron produced to-day differs from the average composition of 20 or 30 years ago quite appreciably. The pig iron to-day contains, perhaps, on the average one per cent more silicon than formerly, and this would mean therefore that, taking the output of iron last year as an illustration, there were 96,526 gross tons more silicon produced than would have been found in a similar quantity of pig iron made 30 years ago. Comparison of analyses of different grades of iron of the present day with those of similar grades made a generation ago will, I think, confirm this statement. The foundrymen have made marked progress since that time, and their literature has kept pace therewith; but it is true, nevertheless, that in the feverish haste to bring to public notice supposedly new discoveries a good deal of "unripe fruit" has been gathered which has withered almost immediately. After a while some sharp pruning will have to be performed in order that the budding tree of foundry knowledge may put forth only healthy sprouts.

When one investigator finds that an infinitesimal amount of aluminum added to cast iron in a ladle produces marvelously beneficial effects of ominous character, and others fail to discover any such results; when one finds that pouring test-bars or castings with dull iron makes them stronger, and others find the reverse; when one finds that shaking test-bars or castings in a bag or barrel not only changes the carbon in the metal from the combined to the graphitic form, or vice versa, but actually in some mysterious manner increases the total carbon in such castings, while others find nothing of the kind; and while there are

scores of other similar contradictory observations and statements spread upon the proceedings of technical societies and published broadcast in this country and in Europe—it is evident that there is need for a good deal of pruning before we can be sure that we have cut off all dead wood.